

3 60729
Mr. Jake Eisel
Century Oil and Gas Corporation
7887 East Belleview, Suite 800
Englewood, Colorado 80111

Dear Mr. Eisel:

You are hereby requested to submit permit applications for the following wells by July 30, 1984:

Field

NW Poplar

Well Name

Goings No. 1
Vickers No. 6-15
Clark No. 1
Cox No. 1

EPA is requiring permit applications for these wells for the following reasons: 1) The agency has determined that salt water disposal (SWD) wells pose a significant threat to Underground Sources of Drinking Water (USDW's) in this area and is therefore permitting them as soon as possible and; 2) EPA has received assertions from the Bureau of Indian Affairs (BIA) of ground water contamination as a possible result of salt water disposal activities on the Fort Peck Indian Reservation. Since the East Poplar and Northwest Poplar fields are the area of greatest concern to the tribe and the BIA, we are requesting that permit applications for wells from these fields be submitted first.

Please complete one of the enclosed application forms for each well listed by July 30, 1984. Be sure that all the applications are complete and that all required attachments are included. Submit the completed applications to:

Chief, Drinking Water Branch
U.S. Environmental Protection Agency (8WM-DW)
1860 Lincoln Street
Denver, Colorado 80210

The SWD wells listed above may continue to operate under current authorization by rule until:

The effective date of a permit (activities will then be authorized by permit);

The denial of a permit (the well will no longer be authorized to inject); or

The owner or operator fails to submit the permit application within the time period specified in this notice (at which time the authorization to inject will be revoked).

I encourage you to contact either Richard Long in the EPA Denver Regional Office (Phone: (303) 844-3914) or William Engle in the EPA Montana Operations Office (Phone: (406) 449-5414) as soon as possible if you have any questions.

Sincerely yours,

John F. Wardell, Director,
Montana Operations Office

Enclosures: Permit Application Forms

RECEIPT FOR CERTIFIED MAIL

NO INSURANCE COVERAGE PROVIDED
NOT FOR INTERNATIONAL MAIL

(See Reverse) 643

* U.S.G.P.O. 1983-403-517	
Sent to	Jack B. McWilliams
Company	Century Oil and Gas
Address	7887 East Bellevue Ave.
City	Englewood, Colorado 80111
Postage	
Certified Fee	
Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to whom and Date Delivered	
Return receipt showing to whom, Date, and Address of Delivery	
TOTAL Postage and Fees	\$
Postmark or Date	

AUG 21 1984

Ref: 8WM-DW

Jack B. McWilliams
Century Oil and Gas Corporation
7887 East Bellevue Avenue
Englewood, Colorado 80111

Re: Underground Injection Control (UIC)
Permit Applications for:
Vickers #1 SWDW (Per. No. MTS21PR-0002)
Goings #1 SWDW (Per. No. MTS21PR-0003)
Clark #1 SWDW (Per. No. MTS21PR-0004)

Dear Mr. McWilliams:

On July 30, 1984, we received your applications for UIC permits to allow the injection of produced brine into the above-referenced wells in the Northwest Poplar field, Montana. We have determined that there are a number of deficiencies and/or parts missing from the applications, and will not be able to declare the applications complete and begin processing your application until they have been received. Certain deficiencies are common to all three of the applications and they are listed below. Deficiencies specific to each well follow the general listing under the well name. The problems that must be addressed on each of the three permit applications are as follows:

1. SIGNATORY: The person who signs the permit application must be either: 1) A principal executive officer of at least the level of a Vice-President or; 2) A duly authorized representative so identified in writing by a Vice-President or higher. See 40 CFR Section 144.32 (a) and (b).

2. DESCRIPTION OF INJECTION OPERATION: In the interest of expediency and clarity, please submit a brief (one or two paragraph) description of each injection operation (e.g., Well # A is injecting into the X formation and the injection fluid will be composed of produced water from well #'s B and C, producing from the Y formation). See 40 CFR Section 144.31(e)(1).

3. AREA OF NOTIFICATION: You are required to give separate notice of intent to apply for a permit to each owner or tenant of the land within a quarter-mile of the subject well. See 40 CFR Section 147.1355(b). When you have given notice, please submit a list of the names and addresses of the owners of record to whom you have sent notice to this office.

8WM-DW
RR Long
8/8/84

8WM-DW
Cathy
8/8/84

8WM-DW
Emmette
8/10/84

BRC
Hobson
8/16/84

RS

4. INDIAN LANDS: All three wells are located at 29N, 50E (Sections 6, 20 and 27). It appears from our maps that all three are located on the Fort Peck Indian Reservation, yet you indicate that only the Goings #1 is on Indian Lands. Please clarify. Permit applicants for injection wells on or within one-half mile of Indian Lands must extend the area of notification to one-half mile of the subject well. See 40 CFR Section 147.1355(c).

5. NAME AND DEPTH OF USDW's: Attachment E (Name and Depth of USDW) requires a submittal of data on USDW's which may be affected by the injection operation. It is EPA policy to expect that any Underground Source of Drinking Water (USDW) overlying an injection zone has the potential for becoming contaminated by that injection. The data submitted as Attachment E is inadequate for our review procedures. There are other USDW's overlying injection zones besides the Judith River (e.g., Fox Hills, Hell Creek, and the Fort Union, all of which meet the definition of a USDW). Please elaborate on your submittals for each permit, giving us the geologic name and depth to the bottom of all USDW's occurring above the injection zones.

6. GEOLOGICAL DATA ON INJECTION AND CONFINING ZONES: With reference to Attachment G (Geologic Data), the geologic data submitted must be expanded upon. Please submit, in narrative form, the appropriate geologic data on the injection zone and confining zones including: lithologic description; geological name; thickness; depth and fracture pressure (and how the fracture pressure was determined). If possible, please submit a local geological map plus a site-specific stratigraphic column.

7. OPERATING DATA: Attachment H (Operating Data) requires that the average and maximum daily injection rate, volume and pressure be established in the permit application. You have stated the average rate, volume and pressure, but not the maximum. Please do so for each well.

WELL-SPECIFIC DEFICIENCIES

In addition to addressing the issues mentioned above for all three wells, please respond to the well-specific issues listed below:

VICKERS #1

1. You have submitted well data for all wells within a one-mile radius of the subject well as Attachment C (Corrective Action). One of the those wells is the Tribal #1. The data submitted is unclear. Who owns/operates the Tribal #1? Is it an active producer at this time? If not, what is its status?

2. In Attachment H (Operating Data), you state that water analyses for the two injection source wells are attached. One of the source wells referenced is the Mason #7-16, but no analysis is included for that well. Please submit this analysis or explain why it was not available.

GOINGS #1

1. Since you have stated that the Goings #1 is located on Indian Lands, please indicate whether or not there is a current Bureau of Land Management permit for this well. If there is such a permit, include the permit number.

2. With regard to your submittal for Attachment A (Area of Review Methods), the top portion of the topographic map in Exhibit I is missing. This missing portion is within the one-mile radius of the subject well. Please submit a new topographic map with the missing portion added. In addition, the maps submitted as Exhibit I and Exhibit II do not agree with each other. Specifically, the plotting of wells 27-1 and 27-3 is different on each map. Please check your plotting and resubmit.

CLARK #1

1. Because the Clark #1 had not commenced injection prior to September 2, 1983 (which is the date of publication for the proposed UIC regulations, and the cut-off date for "grandfathering in" aquifer exemptions for existing wells), you may need an aquifer exemption in addition to a permit. Aquifers with less than 10,000 mg/l total dissolved solids qualify as USDW's and must receive an exemption before EPA can issue a permit to inject (see 40 CFR Sections 144.7 and 145.4). The Goings #1 and the Vickers #1, which commenced injection on 3/22/82 and 4/1/83, respectively, were included on our initial injection well inventory and were granted automatic aquifer exemptions upon UIC program approval. In order to determine whether or not an aquifer exemption is necessary, we will need further information on the injection zone including water quality and water use. A copy of the UIC Fact Sheet on aquifer exemptions is attached. If an aquifer exemption is required for the Clark #1 well, continued use of the well is a violation of the Safe Drinking Water Act which subjects you to a penalty of up to ten-thousand dollars (\$10,000) per day of noncompliance (per 40 C.F.R. Section 144.12).

As soon as we receive all the information listed above, we will be able to proceed with processing the permits and the aquifer exemption. Please submit the required information to the Denver Regional office as soon as possible, but no later than September 6th. If you have any questions regarding this letter, or on the status of your applications, please contact Laura Clemmens (for the Vickers #1 well) at (303)844-2731 or Jim Boyter (for the Goings #1 and Clark #1 wells) at (406)449-5486.

Sincerely,

Original signed
John G. Welles

John G. Welles
Regional Administrator



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
1860 LINCOLN STREET
DENVER, COLORADO 80295-0699

File: Century Oil & Gas
Denver Office

Ref: 8MO

JAN 17 1985

Mr. Jack B. McWilliams
Century Oil and Gas Corporation
7887 East Belleview Avenue
Englewood, Colorado 80111

Re: Underground Injection Control
(UIC) Permit for Goings #1 Well
Permit Number: MTS21PR-0003

UIC permit and Aquifer Exemption
for Clark #1 Well
Permit Number: MTS21PR-0004

Dear Mr. McWilliams:

Attached are copies of the Draft UIC Permits and Statements of Basis for the Goings #1 Well and the Clark #1 Well in Roosevelt County, Montana. A Draft Aquifer Exemption is also included for the Clark #1 Well.

Notices should appear soon in the Billings Gazette and the Wolf Point Herald News notifying the public of the opportunity to comment on the draft permit. Separate notices have also been sent to surface land owners within the area of review.

Please note that this is your opportunity to carefully inspect these documents and be sure that you are aware of and agree with all the permit conditions stated therein. The public comment period will run until February 15, 1985. If you have any questions on this action, please call Jim Boyter at (406) 449-5486.

Sincerely,

Max H. Dodson, Director
Water Management Division

Attachments

P 725 767 474

RECEIPT FOR CERTIFIED MAIL

NO INSURANCE COVERAGE PROVIDED
NOT FOR INTERNATIONAL MAIL

(See Reverse)

★ U.S.G.P.O. 1983-403-517

PS Form 3800, Feb. 1982

Sent to <i>Jack B Williams</i>	
Street and No. <i>17887 E. Bellview Ave</i>	
P.O., State and ZIP Code	
Postage	\$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to whom and Date Delivered	
Return receipt showing to whom, Date, and Address of Delivery	
TOTAL Postage and Fees	\$
Postmark or Date	

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(See Reverse) 643

Sent to	Jack B. McWilliams
Century Oil and Gas	
7887 East Bellevue Ave.	
Englewood, Colorado 80111	
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Certified Fee	
Special Delivery Fee	
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Return receipt showing to whom, Date, and Address of Delivery	
TOTAL Postage and Fees	\$
Postmark or Date	

Dick
F-11

AUG 21 1984

Ref: 8WM-DW

Jack B. McWilliams
Century Oil and Gas Corporation
7887 East Bellevue Avenue
Englewood, Colorado 80111

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8/8/84

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Sincerely,

Original signed
John G. Welles

John G. Welles
Regional Administrator

Permit Application & Attachments
(P&A Approval Request)

Correspondence to EPA

Well Located: NENW 27 029N 050E
FORT PECK
POPLAR, NW, ROOSEVELT County
GOINGS #1 SWDW
MT00003
MT2003-0003

NEW 21-

Form Approved OMB No. 2040-0042. Expires 9-30-86

Form 4 UIC	EPA UNITED STATES ENVIRONMENTAL PROTECTION AGENCY UNDERGROUND INJECTION CONTROL PERMIT APPLICATION (Collected under the authority of the Safe Drinking Water Act, Sections 1421, 1422, 40 CFR 144)	I. EPA ID NUMBER T/A C
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READ ATTACHED INSTRUCTIONS BEFORE STARTING FOR OFFICIAL USE ONLY

Application approved mo day year	Date Received mo day year	Permit/Well Number	Comments
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II. FACILITY NAME AND ADDRESS

Facility Name
Goings #1 SWDW
Street Address
Northwest Poplar Field
City
Roosevelt County State **MT** ZIP Code

III. OWNER/OPERATOR AND ADDRESS

Owner/Operator Name
Century Oil & Gas Corporation
Street Address
7887 East Bellevue, Suite 800
City
Englewood State **CO** ZIP Code **80111**

IV. OWNERSHIP STATUS (Mark 'x')

☐ A. Federal ☐ B. State ☒ C. Private
☐ D. Public ☐ E. Other (Explain)

V. SIC CODES

1311

VI. WELL STATUS (Mark 'x')

☒ A. Operating Date Started
mo day year **3 22 82**
☐ B. Modification/Conversion ☐ C. Proposed

VII. TYPE OF PERMIT REQUESTED (Mark 'x' and specify if required)

☒ A. Individual ☐ B. Area Number of Existing wells **1** Number of Proposed wells Name(s) of field(s) or project(s)
Northwest Poplar

VIII. CLASS AND TYPE OF WELL (see reverse)

A. Class(es) (enter code(s)) **II** B. Type(s) (enter code(s)) **D** C. If class is "other" or type is code "x," explain D. Number of wells per type (if area permit)

IX. LOCATION OF WELL(S) OR APPROXIMATE CENTER OF FIELD OR PROJECT

A. Latitude			B. Longitude			Township and Range			X. INDIAN LANDS (Mark 'x')					
Deg	Min	Sec	Deg	Min	Sec	Twsp	Range	Sec	1/4 Sec	Feet from	Line	Feet from	Line	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
						29N	50E	27	NW	528	N	2065	W	

XI. ATTACHMENTS

(Complete the following questions on a separate sheet(s) and number accordingly; see instructions)
FOR CLASSES I, II, III (and other classes) complete and submit on separate sheet(s) Attachments A — U (pp 2-6) as appropriate. Attach maps where required. List attachments by letter which are applicable and are included with your application:

XII. CERTIFICATION

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

Jack B. McWilliams, Production Manager
Jack B. McWilliams
RECEIVED
JAN 07 1985
EPA REGION VIII
DRINKING WATER BRANCH

ATTACHMENTS TO FORM 4
Goings #1 SWDW

- A. AREA OF REVIEW METHODS (Exhibit I)
 - fixed radius of 1/4 mile from the wellbore (Montana)
- B. MAPS OF WELLS/AREA AND AREA OF REVIEW (Exhibits I, II, III)
 - topographic map and disposal facility layout
- C. CORRECTIVE ACTION PLAN AND WELL DATA (Exhibits IV, V, VI, VII)
 - well data for all wells within one mile: Goings #27-3, Goings #1 SWDW, Robbins #22-15, Goings #27-1
- D. MAPS AND CROSS SECTIONS OF USDWS
 - does not apply to Class II wells
- E. NAME AND DEPTH OF USDWS (Class II) (Exhibit VIII)
 - geologic name and depth to bottom of all underground sources of drinking water
- F. MAPS AND CROSS SECTIONS OF GEOLOGIC STRUCTURE OF AREA
 - does not apply to Class II wells
- G. GEOLOGICAL DATA ON INJECTION AND CONFINING ZONES (Class II) (Exhibit VIII)
 - geologic data on injection zone and lithologic description, geological name, thickness, depth and fracture pressure
- H. OPERATING DATA (Exhibits IX, X)
 - operating data and disposal fluids characteristics
- I. FORMATION TESTING PROGRAM
 - does not apply to existing Class II wells
- J. STIMULATION PROGRAM
 - no stimulation program proposed
- K. INJECTION PROCEDURES (Exhibit XI)

- L. CONSTRUCTION PROCEDURES (Exhibit XII) .
- M. CONSTRUCTION DETAILS (Exhibit XII)
- N. CHANGES IN INJECTED FLUID
 - Class III wells only
- O. PLANS FOR WELL FAILURES (Exhibit XIII)
 - contingency plans
- P. MONITORING PROGRAM
 - daily pumper visual inspection
- Q. PLUGGING AND ABANDONMENT PLAN (Exhibit XIV)
- R. NECESSARY RESOURCES (Exhibit XV)
- S. AQUIFER EXEMPTIONS
 - not applicable
- T. EXISTING EPA PERMITS
 - none
- U. DESCRIPTION OF BUSINESS (Exhibit XVI)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

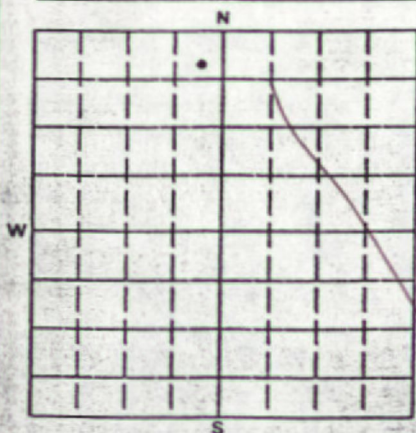
EXHIBIT X IV

PLUGGING AND ABANDONMENT PLAN

NAME AND ADDRESS OF FACILITY

Goings #1 SWD
NENW Section 27-T29N-R50E
Roosevelt County, Montana

NAME AND ADDRESS OF OWNER/OPERATOR

Century Oil & Gas Corporation
7887 East Belleview, Suite 800
Englewood, Colorado 80111LOCATE WELL AND OUTLINE UNIT ON
SECTION PLAT — 640 ACRES

STATE

MT

COUNTY

Roosevelt

PERMIT NUMBER

NA

SURFACE LOCATION DESCRIPTION

NE 1/4 OF NW 1/4 OF 1/4 SECTION 27 TOWNSHIP 29N RANGE 50E

LOCATE WELL IN TWO DIRECTIONS FROM NEAREST LINES OF QUARTER SECTION AND DRILLING UNIT

Surface Location 528 ft. from (N/S) Line of quarter section
and 2065 ft. from (E/W) Line of quarter section

TYPE OF AUTHORIZATION

- ☒ Individual Permit
☐ Area Permit
☐ Rule

Number of Wells 1

WELL ACTIVITY

- ☐ CLASS I
☒ CLASS II
☒ Brine Disposal
☐ Enhanced Recovery
☐ Hydrocarbon Storage
☐ CLASS III

Lease Name Goings

Well Number 1

CASING AND TUBING RECORD AFTER PLUGGING

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☒ The Balance Method
☐ The Dump Bailer Method
☐ The Two-Plug Method
☐ Other

SIZE	WT(LB./FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE
8 5/8	24	302	302	12 1/4
5 1/2	14	1186	1186	7 7/8

CEMENTING TO PLUG AND ABANDON DATA:

	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inches)	5 1/2						
Depth to Bottom of Tubing or Drill Pipe (ft.)	1116						
Sacks of Cement To Be Used (each plug)	144						
Slurry Volume To Be Pumped (cu. ft.)	153						
Calculated Top of Plug (ft.)	Surface						
Measured Top of Plug (if tagged ft.)	NA						
Slurry Wt. (Lb./Gal.)	16.4						
Type Cement or Other Material (Class III)	Class H						

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED (If any)

From	To	From	To
1028	1038		
1080	1096		
1108	1116		

Estimated Cost to Plug Wells

\$10,000

See revised plan

CERTIFICATION

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

NAME AND OFFICIAL TITLE (Please type or print)

Ted D. Brown, Staff Engineer

SIGNATURE

DATE SIGNED

7/27/84

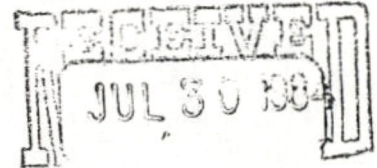


Century Oil & Gas Corporation

Suite 800
7887 E. Belleview Avenue
Englewood, Colorado 80111

Phone 303 694-1533
RCA Telex 216149

July 17, 1984



EPA REGION VIII
DRINKING WATER BRANCH

Chief, Drinking Water Branch
U. S. Environmental Protection Agency
(8WM-DW)
1860 Lincoln Street
Denver, Colorado 80295

Re: Permit Applications for
Century Oil & Gas Corporation
Produced Water Disposal Wells
Goings #1, Vickers #1, Clark #1
Northwest Poplar Field
Roosevelt County, Montana

Gentlemen:

Further to that letter request of June 20, from John F. Wardell (REF: 8WM-DW) and my telephone conversation with Richard Long of July 11, please find enclosed completed applications for the subject wells referenced above. As the Cox #1 salt water disposal well, mentioned in your June 20 letter, was never drilled, an application for this well is not submitted.

Should you have questions regarding the application, please contact the undersigned.

Very truly yours,

CENTURY OIL & GAS CORPORATION

Jack B. McWilliams
Production Manager

JBM/kw
Enclosures

**RECORD OF
COMMUNICATION**☒ PHONE CALL ☐ DISCUSS ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)

(Record of item checked above)

TO:

Richard Long

FROM:

Jack Mc Williams (694-1538)
Century Oil & Gas

DATE 7/11/84

TIME 1:30 pm

SUBJECT

Century's applications for permits

SUMMARY OF COMMUNICATION

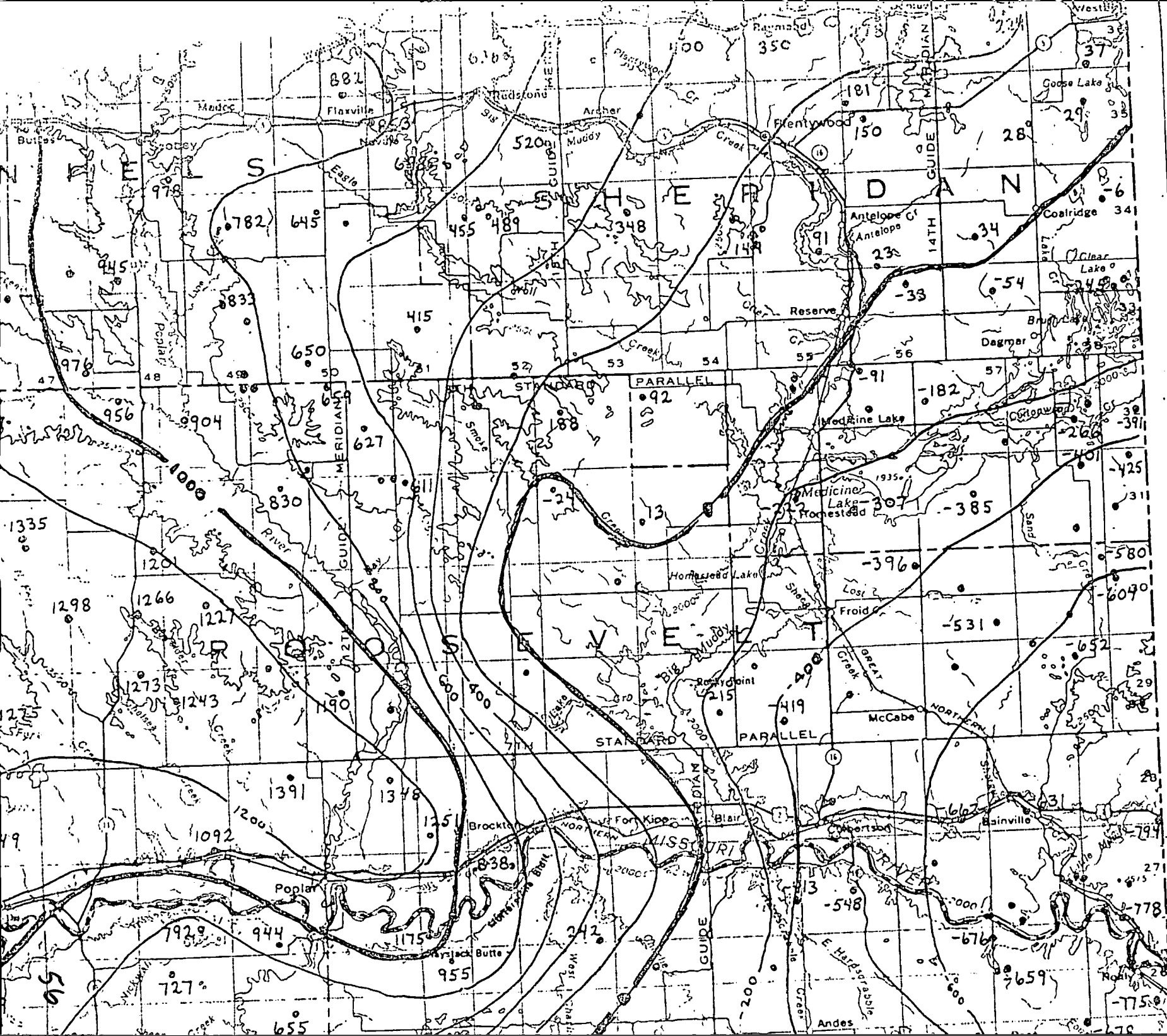
Mr. Mc Williams was putting together his applications for permit per our letter of June 25. He needed to know how to fill out the SIC code portion of the application form. I went to the library and looked up the codes. Crude oil production and natural gas is no 1311. I called him back with the information. I indicated at that time that he did not expect any problems in meeting the July 30 application date.

CONCLUSIONS, ACTION TAKEN OR REQUIRED

INFORMATION COPIES

TO: file folders

JUDITH FORMATION ~~VALUES~~ VALUES



EXPLANATION

Qal

Alluvium

Mainly valley fill consisting of silt, sand, and gravel; includes some terrace deposits and glacial drift of Pleistocene age in some areas; locally includes hot spring tufa. The older part of the alluvium, where present, is probably of Pliocene age.

Qgl

Glacial lake deposits

Mainly silt; believed to have been deposited in lakes formed behind temporary dams of ice or morainal deposits.

Qg

Glacial drift

Morainal and outwash plain deposits of mountain glaciers; mainly ill-sorted and poorly rounded boulders, cobbles, pebbles, and sand; may include alluvium in places.

with marl and

Gravel, sand, and

Tertiary

Ts

Tertiary sedimentary undifferentiated

Clastic deposits in western Montana in valleys, and in most places into formations; mostly poorly sorted gravel, sand, silt, and clay; some tuffaceous material and lenses of lignite and bentonite; in some areas, lava may be included. These rocks are Tertiary in part laid down in lakes and part was formed in streams and fans. These rocks are Tertiary in part as now mapped may even include beds of Cretaceous age. Some late terrace deposits may be included.

Ta

Arikaree formation

Gray sandstone with layers of concretions; contains volcanic ash and, locally, channels filled with conglomerate; known only in southeastern Montana.

Tw

White River formation

Light-colored clay with minor beds of sandstone and local beds of nodular limestone.

Tw

Wasatch formation

Light-colored massive sandstone; drab-colored shale and coal in southeastern Montana; and variegated, dominantly red beds of clay and sandstone in north-central Montana.

Tfu

Fort Union formation

Clay shale, siltstone, and sandstone; local lenses of impure limestone, and numerous lignitic beds; contains Tertiary plant and animal fossils but no dinosaurs; base generally placed at the lowest of the succession of lignite beds within it; includes the Tongue River member, Lebo shale member, and Tullock member.

Khc

Hell Creek formation

Somber-gray sandstone and greenish shaly clay and mudstone containing dinosaur bones; a few thin lignite and subbituminous coal beds.

Kfh

Fox Hills sandstone

Typically shaly sandstone grading upward into massive brownish sandstone with white sandstone of the Colgate member locally at top.

Kb

Bearpaw shale

Dark-gray and brownish clay shale; thick units of nonfissile bentonitic shale; calcareous and ferruginous concretions throughout; contains some thick bentonite beds.

Kjr

Judith River formation

Light-colored sandstone at top; lower third somber-gray siltstone and sandy shale; greenish-gray clay and some lignite beds; includes the Parkman sandstone member of south-central Montana.

Kcl

Claggett formation

Chiefly dark-gray shale with iron-stained concretions; locally sandstone present; numerous bentonite beds near base.

Keu

Kp

Pierre shale

Dark-gray clay shale with calcareous ferruginous concretions and sandy me

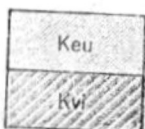
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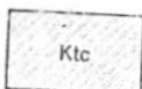
Claggett formation

Chiefly dark-gray shale with iron-stained concretions; locally sandstone present; numerous bentonite beds near base.



Eagle sandstone

Sandstone and shaly sandstone with lignite beds in basal part of upper unit (Keu). The Virgelle sandstone member (Kvi) at base is distinguished where possible. Near Yellowstone National Park rocks incorrectly called Laramie in early reports and now regarded as roughly equivalent to the Eagle sandstone are tentatively mapped as Eagle sandstone.



Telegraph Creek formation

Mainly soft, fissile sandy shale with subordinate amounts of concretionary sandstone.



Nicbrara formation

Gray calcareous shale with limestone concretions; many thin bentonite beds locally.



Carlile shale

Gray shale with calcareous and ferruginous concretions; middle part commonly sandy.



Greenhorn formation

Mainly light-gray marl and calcareous shale.



Belle Fourche shale

Gray siliceous shale with many calcareous and ferruginous concretions and intercalated thin layers of bentonite.

Cody shale

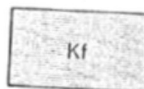
Pierre shale

Dark-gray clay shale with calcareous and ferruginous concretions and sandy members.



Basal part of Cody shale

Gray and dark-gray shale with some sandstone beds; in north end of Big Horn Basin includes the Telegraph Creek formation.



Frontier formation

Mainly gray sandy shale; locally Torchlight sandstone member constitutes upper third and thinner Peay sandstone member is at base; contains some thick beds of bentonite.



Mowry shale

Chiefly light-gray silicified shale and claystone with minor amounts of sandy shale and sandstone; contains some thick beds of bentonite.



Thermopolis shale

Dark-gray shale with some sandstone. The subsurface consists of Muddy sandstone member or Newcastle sandstone member at top, Skull Creek shale member in middle, and Fall River sandstone or First Cut Creek sand of drillers at base.



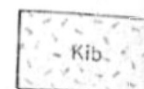
Idaho batholith and associated rocks

Granitic gneiss, quartz monzonite, and mudstone; purplish and gray are common; mainly the Kootenai; in southern part includes strata that have been mapped as Cloverly. Includes Second Cat Creek and Third Cat Creek drillers in central part of State; Sunburst sand of north-central part; and Cut Bank sand of drillers in part. As here mapped, may locally include thin Jurassic age.



Idaho batholith and associated masses

Faintly gneissic quartz monzonite, granodiorite, and similar rocks. The extreme eastern part of the Idaho batholith extends into Ravalli County, Mont. This and nearby masses of similar rocks are shown as associated with the Idaho batholith and designated Ki. Future studies may show that some granitoid masses farther east are also allied to the Idaho batholith or that a few of the masses now grouped with that batholith are younger. Precise dating is impossible at present.



Border zone of Idaho batholith and associated masses

Granitic gneiss and sedimentary rocks, largely unmetamorphosed with granitic material. Because they are not distinguished around some masses that have such border zones.

Diorite
Dark, moderately fine grained bodies; not readily distinguished from the gneisses. Hence in the less well known areas these may remain. These rocks

Colorado
Dark-gray shale and siltstone and sandy units. Includes Skull Creek, Newcastle, Greenhorn, Carlile, and locally Telegraph Creek formations in known areas beds of other age

Thermopolis shale
Dark-gray shale with some sandstone. The subsurface consists of a sandy sandstone member or Newcastle sandstone member, Skull Creek shale member in middle, and Fall River sandstone or First Cat Creek sand of drillers at base.

Ki

Idaho batholith and associated masses
Faintly gneissic quartz monzonite, granodiorite, and similar rocks. The extreme eastern part of the Idaho batholith extends into Ravalli County, Mont. This and nearby masses of similar rocks are shown as associated with the Idaho batholith and designated Ki. Future studies may show that some granitoid masses farther east are also allied to the Idaho batholith or that a few of the masses now grouped with that batholith are younger. Precise dating is impossible at present.

Border

Granitic gneiss and pegmatites with quartz veins; they are not distinct masses that have

Kk

Kootenai formation and associated rocks

Conglomerate, sandstone, shale, and mudstone; purplish and green beds are common; mainly the Kootenai; in southern Montana includes strata that have been mapped as Cloverly formation. Includes Second Cat Creek and Third Cat Creek sands of drillers in central part of State; Sunburst sand of drillers in north-central part; and Cut Bank sand of drillers in western part. As here mapped, may locally include thin units of Jurassic age.

Ju

Jurassic, undifferentiated

Calcareous shale and sandstone; includes the Morrison formation, the Ellis group, Sundance formation, and other rocks of Jurassic age.

Tu

Triassic, undifferentiated

Conglomerate, sandstone, shale, and impure limestone belonging to the Dinwoody and Thaynes formations and other units of Triassic age, and the Chugwater of Triassic and Permian age.

Pu

Permian, undifferentiated

Chert, sandstone, limestone, quartzite, and shale with rock phosphate mostly at base; mainly Phosphoria formation.

Pu

Pennsylvanian, undifferentiated

In western Montana is mainly the Quadrant quartzite but includes limestone and other rocks of Pennsylvanian age so far as present data permit. Farther east other formations of Pennsylvanian or possible Pennsylvanian age are included.

Mu

Mississippian, undifferentiated

Sandstone, shale, and limestone, in part dolomitic, with chert nodules, some quartzite; includes Big Snowy group in central part of State, Madison group in central and southwestern parts; and Hannan and Brazer limestones in the northwestern part; may include small amounts of Pennsylvanian rocks in areas where stratigraphic studies are incomplete.

Du

Devonian, undifferentiated

Comprises Three Forks formation consisting of carbonaceous and calcareous shale with some sandstone and limestone, Jefferson sandstone, and unnamed units of Devonian age.

Ou

Ordovician, undifferentiated

Mainly Bighorn dolomite; near Idaho, Kinnikinic quartzite.

Cu

Cambrian, undifferentiated

Includes formation, in south-central Montana, and other units. Dry Creek shale, Hasmark formation, and other units. Silver Hill formation, Park shale, Meagher shale, Flathead quartzite, and other units. Quartzite of Cambrian age may be mapped in the Helena region, the Striped Peak and Libby formations in southwestern Montana, and near Missoula, and other

pCb

Missoula group

Includes red, brown, or purple argillite; sandy or quartzitic sandstone, and variously impure quartzite and limestone. The latter formations are similar to the Siyeh limestone of the Pierre group. The Missoula group includes numerous named formations, most of which cannot be traced with confidence from their type localities. Among these are the Marsh and the Helena region, the Striped Peak and Libby formations in southwestern Montana, and near Missoula, and other

pCb

Purcell basalt

Dark greenish-gray altered effusive basalt; in Glacier National Park it is near base of Missoula group; but in other localities, mainly in Canada, it is reported in other stratigraphic positions.